THERMAL RESISTANCE OF INTERLOCKING BLOCK WALL WITH INFILL

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Project Report submitted as partial fulfillment of the
requirements for the award of the degree of
B.Eng. (Hons.) Civil Engineering

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

JULY 2015

ABSTRACT

In the era of global warming and decreasing resources material today, the awareness of the important of the energy efficient building have increased. A lot of studies about thermal insulation material and thermal conductivity have been carried out to find the solution due to global warming. Interlocking block or Compress Stabilized Earth Block (CSEB) have been widely use today due to its effectiveness especially in reducing the cost and time. Sawdust and polystyrene can act as thermal insulation and hence the usage of sawdust and polystyrene as thermal insulation in building can decrease the waste material from the construction. This study have been carried out to determine the thermal conductivity of interlocking block wall with three different type of infill which are sawdust, polystyrene and polystyrene mix with cement. The thermal resistance test have been conduct based on MS 1532:2002 using guarded hot box method. The higher the R-value or thermal resistance reading means the better the thermal resistance of the material. The result for the sawdust as infill is 1.71 m^2 K/kW, polystyrene infill is 2.12 m^2 K/kW, and polystyrene mix with cement is 1.54 m^2 K/kW. The results show that wall with polystyrene as infill have better thermal insulation than sawdust as infill and polystyrene mix with cement as infill.

ABSTRAK

Dalam era pemanasan global dan pengurangan bahan sumber hari ini, kesedaran tentang pentingnya bangunan cekap tenaga telah meningkat. Banyak kajian tentang bahan penebat haba dan kekonduksian haba telah dijalankan untuk mencari penyelesaian akibat pemanasan global. Saling blok atau Compress Stabil Bumi Sekat (CSEB) telah digunakan secara meluas hari ini kerana keberkesanannya terutama dalam mengurangkan kos dan masa. Habuk papan dan polistirena boleh bertindak sebagai penebat haba dan dengan itu penggunaan habuk papan dan polistirena sebagai penebat haba di dalam bangunan boleh mengurangkan bahan buangan daripada pembinaan. Kajian ini telah dijalankan untuk menentukan keberaliran haba blok dinding dengan tiga jenis yang berbeza isian yang habuk kayu, polistirena dan polistirena campuran dengan simen. Ujian rintangan haba telah kelakuan berdasarkan MS 1532: 2002 dengan menggunakan kaedah kotak panas dijaga. Semakin tinggi nilai-R atau bacaan rintangan haba ertinya lebih baik rintangan haba bahan. Keputusan bagi habuk papan sebagai isian adalah 1.71 m^2K/kW, polistirena infill 2.12 m^2K/kW, dan campuran polistirena dengan simen 1.54 m^2K/kW. Keputusan menunjukkan bahawa dinding dengan polistirena sebagai isian mempunyai penebat haba yang lebih baik daripada habuk kayu sebagai isian dan polistirena campuran dengan simen sebagai isian.

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CSEB	Compressed Stabilized Earth Block
MS	Malaysian Standard
OPC	Ordinary Portland Cement
BS	British Standard

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Urbanization and socio-economic are among the factors that prompt to the invention of interlocking block or dry masonry stack. In Africa, interlocking block was invented to solve the housing problem due the rise in costs of land and building materials while in Thailand, interlocking block was develop to reduce the usage of timber.

Interlocking block reduces the usage of industrial products like cement and relies on local resources. It is considered to an effective and environmental friendly technology because it consumes less production energy, reduces deforestation, decrease the utilization of non-renewable resources and produce less waste from construction process.

1.2 PROBLEM STATEMENT

Wall is one of the main components in construction of the building. Wall will transfer the load from above such as upper floor and roof truss and transfer it to the foundation below the ground. Wall also acts as a rain control layer, an air control layer, a vapor control layer and a thermal control layer. In some countries especially cold climate countries in North America and Europe, wall with insulation materials was built to give some heat during the winter. Heat will always flow from a warm area to a cold one. In winter, the colder it is outside, the faster heat from the house will escape into the surrounding air. Thermal resistance is one of the main aspects in construction of houses. Builders are finding methods to insulate the wall rather than using the conventional way.

Due to global warming, people today prefer to use air conditioner in their house. The usage of air conditioner is one the main factor contributes to the global warming. Although there are energy efficient air conditioners, not all people can't afford to buy it. Hence, this study will investigate the role of infill in retaining heat especially in the wall.

1.3 OBJECTIVES

The objectives of this proposed topic are as follows:

i. To determine the compressive strength of the blocks

ii. To determine the thermal resistances of interlocking block walls with three different types of infill.

iii. To compare which infill have better thermal resistance.

1.4 SCOPE OF STUDY

The scope of this proposed topic is focusing on:

1. To produce interlocking Compress Stabilized Earth Blocks (CSEB).
2. To test compressive strength of the blocks.
3. To design and build block wall with 1x1.05 m dimension using interlocking blocks.
4. To test the thermal resistance of the wall with three different conditions:
    a) Wall with sawdust as infill
    b) Wall with polystyrene as infill
    c) Wall with polystyrene mix with cement as infill

1.5 RESEARCH SIGNIFICANCE

With this research, the usage of industrial waste material such as sawdust and the introduction of Styrofoam as insulation material in interlocking block could be an alternative to conventional masonry wall especially in Malaysia.

This research can promote to the application of energy efficient building and give better understanding to the usage of Styrofoam and sawdust as insulation material in interlocking block construction.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

An energy efficient building envelope contains both a thermal barrier and an air barrier. The key to an effective thermal barrier is proper installation of quality insulation products. A house should have a continuous layer of insulation around the entire building envelope. Studies show that improper installation can cut performance by 20 % or more (Fehr 2009). There is several type of insulator available nowadays as the whole world is moving towards green environment and the increasing of green energy building demand.

2.2 INTERLOCKING BLOCK

Urbanization, housing shortage, and deforestation is among the problem that lead to the search of appropriate, easy, fast, and cost effective of new wall construction. In Thailand, 70 % forest covered in 1936 has decreased to 55 % only in 1961 and now around 30 % is left. Hence, the government developed a research to use alternative materials to be used in construction especially in rural area. Among the solution is

mortarless technology using dry stack interlocking blocks. Thailand Institute of Scientific and Technological Research (TISTR) have proved that house built with interlocking block is cheaper than house built by timber. (Weinhuber, 1995)

Interlocking block usage increase around the world and have been accepted as one of the new technologies that is more effective than the conventional way. Interlocking blocks have a lot of advantage such as increasing the construction productivity, reduction in construction duration and labor use and reduced construction cost. The cost of construction of the wall using interlocking block is estimated 40 % lower than using more conventional materials (Kitingu, 2009)

There are many systems or interlocking block types that have been develop. Among them is Mechano System which has been developing in Peru. Mechano System not involved interlocking geometry and it gain it's stability through grouting process. Sparfil System develops in Canada, which develop by using light weight concrete (Jasim, 2014). There other systems are Allan Block System, Auram System, Hyner Blocks, Hydraform Systems, Putra Blocks, and Solbric System.

Interlocking blocks followed a few concept or principles where the blocks are shaped with projecting parts. It fit exactly into depression in the blocks placed above, such that they are automatically aligned horizontally and vertically. Thus, bricklaying is possible without special masonry skills. There were vertical hole in the block to reduce the weight of the block and to insert steel rods for reinforcement, and/or to pour liquid mortar which runs through the full height of the wall, making it more stable. (Rohaizad, 2010)

Table 2.1: Review of performance Studies (Source: Rohaizad, 2010)

Name Of system	Block type and material	Interlocking mechanism	Salient observations
Mechano system, Peru	Hollow (sand time)	No interlocking geometry-stability only through grouting	a) Compression test on prism (20 % reduction in strength than mortar-laid masonry) b) Diagonal tension test, horizontal reinforcement increase diagonal strength and provide ductility
Modified H-block, USA	Hollow (concrete)	Tongue and groove in head joint	a) Axial compression tests on hollow (average efficiency of 49 %) and grouted prisms b) Higher flexural strength on grouted specimens
Sparfil System, Canada	Hollow (light weight concrete)	No geometric interlocking	a) Compressive strength is affected by individual block strength and surface bonding provides flexural resistance
Haenar system, USA and Canada	Hollow (concrete)	Projecting nibs in bed joint, tongue and groove head joint	a) Concerning and eccentric and flexural tests on grouted specimens b) Compressive Strength higher than conventional masonry c) Benefits of strain gradient affects greater
Spalock system, Canada	Hollow (concrete)	Through geometry and	**Axial compression**-Ungrouted: Face fell

		stacking pattern	cracking close to ultimate load. Grouted specimens: Face shell cracking well before ultimate load due to lateral tensile strains in grout a) Lateral load tests on hollow block wall specimens b) Finite-element analysis to predict stress distribution in bending and moment capacities of dry stack assembly.

Many literatures on interlocking block are produced. However, the results on behavioral characteristics of the block are available for a few only (Ramamurthy, 2005). The development of interlocking blocks reveals that:

a) Many blocks have complex shapes, which appear to have been deliberate, and such intricacies in block geometry (tongue and groove or undercut and dovetail arrangement) necessitate mechanized production methods.

b) The presence of continuity of horizontal and vertical joints from inner to outer face.

2.3 THERMAL INSULATION

Thermal insulation can be refers either to materials used to reduce the rate of heat transfer, or the methods and processes used to reduce heat transfer.

Heat is transferred by from one material to another by conduction, convection or radiation. Insulators are used to minimize that transfer of heat energy. The R-value is an indication of how well a material insulates.

Thermal insulators are those materials or combination of several materials which retard the flow of heat energy. Installation of thermal insulation can significantly reduce the thermal energy lost from thermal heat storage.

Insulation materials can be made from many different type or forms such as loose-fill form, blanket bat or roll form, in place foamed, rigid form or reflective form. (Gertrude 2011).

2.3.1 Styrofoam

Styrofoam, or polystyrene foam, is petroleum-based plastic foam with exceptional insulated properties. Styrofoam is 95 % air, allowing it to trap warm air and prevent heat loss when used as insulation in a building or a disposable coffee cup. The trapped air inside the Styrofoam prevents heat from effectively passing out making heating system more efficient.

Ray McIntire, scientist from Dow Chemical Company, accidentally invented foamed polystyrene or Styrofoam. McIntire tried to make a new rubber-like polymer by combining styrene with isobutylene, a volatile liquid, under pressure. The result was foam polystyrene with bubble, 30 times lighter than regular polystyrene. The Dow Chemical Company introduced Styrofoam products to the United State in 1954. (Friend, 2005)

2.3.2 Sawdust

Sawdust is a by-product of cutting, grinding, drilling, sanding, or otherwise pulverizing wood with a saw or other tool. It is composed of fine particles of wood (Junior, 2014).

Sawdust or cellulose could offer the development business a powerful, ecologically cordial option to tradition protection as it has moderately high warm qualities (Cordis, 2012).

CHAPTER 3

MATERIALS AND METHODOLOGY

3.1 INTRODUCTION

This chapter will describe the procedure and execution of works in details. It will discuss from the preparation of sample to the testing procedure that involved in this study.

3.2 SAMPLE PREPARATION

The material that will be used to produce the interlocking block need to be prepared first. The materials used are cement, fine aggregate, laterite soil.

3.2.1 Cement

There are mixed bags of concrete accessible in the business. For this study, the Ordinary Portland Cement (OPC) is chosen. The choice focused around the regular practice as this kind of bond is generally utilized as a part of development procedure.

There are a lot of cements available but for this studies OPC is used because it is the most common and widely used in the market.

3.2.2 Laterite Soil

Laterite soil is obtained from nearby location at University Malaysia Pahang and used as one of the component of the interlocking block where the laterite soil will be mix with the cement and sand in the proportion of 1.4:2:6.

3.2.3 Fine Aggregate

In this study, fine sand or river sand will be used as fine aggregate. River sand is the most commonly and easiest fine aggregate that can be get from the supplier.

3.2.4 Sawdust

Sawdust can be getting from the sawmill nearer, Sawmill Gambang Sdn Bhd, and will be used as one of the infill in the interlocking block wall.

3.2.5 Styrofoam

Styrofoam can be getting from any bookstall nearer and will be used as one of the infill in the interlocking block wall.

3.2.6 Water

Water is required in mixing procedure. The amount water content will be used for mixing process is 10 % from the weight of the sand.

Figure 3.1: Styrofoam board

3.3 INTERLOCKING BLOCK WALL

For this study, the interlocking block produced by using ratio 1.4:2:6 of cement, laterite soil and sand mixture. The interlocking block dimension is 100x125x300 mm for regular size, 100x150x300 mm for corner block and half block size is 100x125x150 mm. First, the cement, laterite soil and sand need to be weight according to the ratio which is 6 kg for normal block and 6.7 kg for corner block. The batch will be mix by mixer machine. Then water will be added to the mixture. The weight of water used is 10% from the weight of sand. Then the batch will be poured into the mould of hydraulic press machine to produce the block.

Figure 3.2: Hydraulic Press Machine

The finish blocks will be used to produce three set of wall with 1.0x1.05m dimension. 35 blocks is used for each set of wall with overall 105 total blocks is used for the three set of walls. For each set of the wall, a total of 10 layers of interlocking block is need.

Reinforcement or rebar is place at every corner of the wall to make sure the wall is steady and not moving. After half of the wall is build (5 layers of interlocking blocks), the wall is grouted with three type of infill as have been mention in the objective to ensure all cavity in the hollow section is filled. After the wall is finished, the top and the wall surface will be grouted with mortar to create a solid wall. The wall then will be covered with the plywood-Styrofoam panel.

Figure 3.4: Reinforcement at interlocking block walls

Figure 3.5: Polystyrene as infill of the wall

Figure 3.6: Sawdust as infill of the wall